AMYGDALA $z \mapsto z^2+c$

A Newsletter of Fractals & $\mathcal{M}$ (the Mandelbrot set)
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THE MONASTIC SECTS

— John Dewey Jones

Preamble

Amygdala #1 featured an extract from the PhD thesis of Dr Martin Dace [Da87]. Dr Dace had originally been concerned to explain the proliferation of exotic cults, generally known as the Amygdalan Sects, that followed the collapse of the first Terran spacefaring cultures. In course of this research, he serendipitously discovered the cause of that collapse — the finest minds and fastest computers of Terran culture had come upon the Mandelbrot Object, which had seduced them from more mundane tasks to the contemplation of its inexhaustible beauty. Pursuing their vision down the branching corridors of complex space, they forgot the world, forgot the maintenance routines and scheduling algorithms, the control of traffic and the disposal of waste; and the web that held their civilization together grew slack, sagged and tore apart. As a final irony, the collapse of their civilization had taken with it the computers, their sole gateway to the vision of the Object. Now, disconsolate, they squatted in the rubble, mourning their lost vision.

It was in this context that the Sects grew up. One of these sects has been described in the extract from Dace's thesis printed in Amygdala #1. The further extract given here presents what is known concerning two monastic Amygdalan orders, the Brethren of the Hidden Path and the Adepts.

I arrived at the Abbey of the Adepts just before nightfall, and joined the monks at evensong. Their chapel was a disappointment to me — I remembered the glorious stained-glass of the Ithaca Temple, the many-sequined altarcloths of Yorktown Heights — while everything here spoke of austerity. The walls were granite, unrelieved by tapestry or wooden ornament, and the single window was of clear glass, the letters of the Formula cut deeply into it.

After the reading — a long passage from the works of St. Benoit — we went in to supper. I sat at the High Table with the Abbot; during our meal, he described for me the religious life of the monks:

"When the old civilization collapsed, the founders of our order asked themselves a deep question: was it the true Object we sought with our plotters and our display screens, or was it only a model, a faint analogy? For consider: the Object in its true nature is *not* colored, nor does any particular integer appear in its definition. There are those — the Literalists of Santa Clara, for example — who hold that the use of color in depictions of the Object merely reveals a structure already present, as a suitable stain may reveal a new anatomical feature in a section of the brain stem. Our founders, however, held to the view that the Object is essentially unknowable by physical means. For any true representation of the Object would require an infinite range of colors — or more generally, an infinite range of sensibles of some sort associated with the integers — and since we can display only a finite number of sensibles, we cannot succeed in reproducing even an infinitesimal fraction of the Object's glory. Whatever can be displayed on a screen can serve only as a symbol, in the same way as the cross symbolises the god of the Christians. Or, at best, our pictures of the set can serve as an arrow, pointing in the direction of an infinitely distant goal."

"How then," I asked, "do your monks approach the Object?"

"We know that the eyes can perceive details and gradations of color finer than any monitor could ever display. Just as the eyes are finer and more subtle than the monitor, so is the mind finer and more subtle than the eyes. And the soul is yet finer and subtler than the mind. Therefore, let the monk withdraw into a quiet place and, withdrawing his senses like the limbs of a tortoise, let him fix his thoughts steadfastly upon the Object.

"We recognise two paths to the Object: the sleeping path and the waking path. The novice is introduced to both disciplines, and encouraged to pursue whichever he shows greater aptitude for. Monks on the sleeping path spend the day in menial tasks around the Abbey. In the evenings they take a light meal, unleavened wheat bread and the dried berries of a certain shrub that grows on the slopes of this mountain. Most commonly their sleep is uneventful and their dreams mundane, but occasionally they will wake with a most vivid recollection of some part of the Object. Some describe their dreaming visions as composed of pure, jewel-like colors; others speak of a pattern of abstract relationships; others again have said that their dreams have been too clear and distinct to describe in words.

"The waking monks, on the other hand, rise at three in the morning and go to the summit of the mountain, where they sit in a row and gaze steadfastly in the direction of Aldebaran — we don't believe in any causal connection between Aldebaran and the Object, you understand, but we have found the reddish light of that star to stimulate the mathematical vision we seek."

I talked with various monks during my stay. They do seem to have a remarkable mental facility for imaging the Object, comparable to the extraordinary powers of idiot savants and calculating prodigies. I have personally witnessed initiates giving lengthy descriptions of 'journeys' within Seahorse Valley, using the sacred language the sect has developed for this purpose.

The Brethren of the Hidden Path broke away from the Adepts several centuries ago, and describe themselves as rationalists rather than mystics. Their central belief is that there exists a NorthWest passage to the Object, a simple mathematical procedure which will yield an accurate and detailed picture of any chosen region. Any interesting field of mathematics, they argue, lies on many different pathways: the transcendental number π, for example, appears as the ratio of a circle's circumference to its diameter, as the solution of the infinite equation

$$x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots = 0$$

and as the square of the integral

$$\int_{-\infty}^{\infty} e^{-x^2} dx$$

Now the Object, like π, is part of the deep structure of the mathematical universe, as is shown by its recurrence in many apparently unrelated contexts. Therefore it too must lie at the meeting place of many paths, and it may be that at least one of those paths can be traversed with pencil and paper. In evidence of this, they cite the visions of the Adepts, which, they say, can only have been achieved through unconscious use of the hidden path.

I stayed among the Brethren until early spring, then crossed the mountains, seeking for news of the Cult of the Object Incarnate. [to be continued (possibly)].

FISH-EYE IMAGES

— John Dewey Jones

Ever wanted to see just how a striking image fits into the Big Picture? The 'fish-eye' technique allows you to display the image in full detail, and at the same time get a panoramic view of its surroundings. In slide 215 of the slide supplement accompanying this issue, we take Charles Fitch's image from Amy #9 and look at it through the fisheye. We see that it's an island attached to a long, curving filament of the mane of a sea-horse. Looking downwards and leftwards along the coastline we see the heads of other seahorses. To the right of the picture are the calm shallow waters filling Seahorse valley. Then, beyond them, we see the further shore and the heads of other, distant horses.

The fisheye technique consists simply in varying the interval in the complex plane corresponding to the gap between adjacent pixels on the display screen. Here's the code I used for a different (but similar) image:

```
CentrX := -0.776785376;
CentrY := 0.13576353 {Fitch image Center coordinates};
Range1 := 1280 {Number of pixels in horizontal direction};
Range2 := 1024{Number of pixels in vertical direction};
FishEye := 150.0 {Ratio of corner scale to centerscale};
FishFac := $\text{FishEye}^{2.0/\sqrt{[\text{Range1}^2 + \text{Range2}^2]}}$;
Magnify := 1500.0 {Magnification factor at centre};
Xrange := 1.0 / Magnify;
Yrange := 1.0 / Magnify;
Xstep := Xrange/Range1;
Ystep := Yrange/Range2 {Step sizes at the centre};
For Col := 1 to Range2 do
begin
  For Row := 1 to Range1 do
  begin
    Dist := $\sqrt{((\text{Range1}/2 - \text{Row})^2 + (\text{Range2}/2 - \text{Col})^2)}$;
    Fish := $\text{FishFac}^{\text{Dist}}$;
    Xincr := Xstep * Fish;
    Yincr := Ystep * Fish;
    x := CentrX + (Row - Range1/2) * Xincr;
    y := CentrY + (Range2/2 - Col + 1) * Yincr;
    [Now do the Mandelbrot iteration on z = x + iy as usual]
```

THE SLIDES

Those subscribing to the color slide supplement now have C15: four slides of the current series of 24 slides, associated with Amygdala #15.

209. (John Dewey Jones): Composition in Braided Ribbon. A 32-fold decomposition of the view from the Biggest Midget to the Uttermost West. For details see the DECOMPOSITION article in Amy #13, page 2.

215. (John Dewey Jones): A 'fish-eye' picture centered on the Fitch image. See FISH-EYE IMAGES in this issue for details.

397. (Ken Philip): This is a detail from the tendrils above the NE Wart. Program Mandel881. Center = 0.38+0.60i, mag = 300, E.R. = 2, dwell ~ 100.

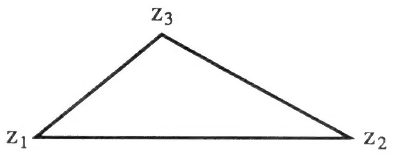
412. (Ken Philip):This is a "4 nines" midget. This is close to the mag. limit of MandelColor 5.5. Program: MandelColor 5.5; contrast CLUT. center=-1.9999875907, mag = 15×10^9, E.R. =100, dwell = 240.

TUTORIAL: AND YET MORE ON GEOMETRIC REPRESENTATION

This episode of the tutorial is devoted to solving the four exercises given in the last episode (Amy #14, page 4).

E14.1. Prove that the points z_1, z_2, z_3 are vertices of an equilateral triangle if and only if $z_1^2 + z_2^2 + z_3^2 = z_1z_2 + z_2z_3 + z_3 z_1$.

We first dispose of an annoying detail: We suppose that the three points are vertices of a non-degenerate triangle, arranged counterclockwise in the order z_1, z_2, z_3:



The cases where these suppositions are false are left to the reader.

It will be useful to recast the problem in terms of the differences d_1, d_2, d_3:

$$d_1 = z_2 - z_1;\ d_2 = z_3 - z_2;\ d_3 = z_1 - z_3;$$

It is apparent that

$$d_1 + d_2 + d_3 = 0$$

Note that $2[z_1^2 + z_2^2 + z_3^2 - (z_1z_2 + z_2z_3 + z_3 z_1)] =$
$z_2^2 - 2z_2z_1 + z_1^2 + z_3^2 - 2z_3 z_2 + z_2^2 + z_1^2 - 2z_1z_3 + z_3^2 =$
$(z_2 - z_1)^2 + (z_3 - z_2)^2 + (z_1 - z_3)^2 = d_1^2 + d_2^2 + d_3^2$, so

$$z_1^2 + z_2^2 + z_3^2 = z_1z_2 + z_2z_3 + z_3 z_1$$

if and only if

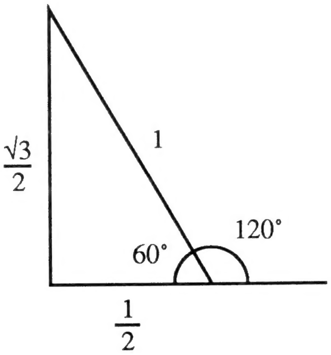
$$d_1^2 + d_2^2 + d_3^2 = 0 \qquad (14.1.1)$$

That d_1, d_2, d_3 are three sides of an equilateral triangle can be expressed algebraically: each side is the previous side rotated through an angle of 120°:

$$d_2 = \rho d_1,\ d_3 = \rho d_2,\ d_1 = \rho d_3, \text{ where } \rho = e^{2\pi i/3}$$

We can now express the problem as follows:
$d_1^2 + d_2^2 + d_3^2 = 0$ **if and only if** $d_2 = \rho d_1, d_3 = \rho d_2, d_1 = \rho d_3$, where $\rho = e^{2\pi i/3}$.

If: Suppose $d_2 = \rho d_1, d_3 = \rho d_2, d_1 = \rho d_3$, where $\rho = e^{2\pi i/3}$. Then $d_1^2 + d_2^2 + d_3^2 = d_1^2(1 + \rho + \rho^2)$. But $\rho = e^{2\pi i/3} = \cos(120°) + i \sin(120°) = -1/2 + \sqrt{3}i/2$.



Likewise $\rho^2 = e^{4\pi i/3} = \cos(240°) + i \sin(240°) = \cos(-120°) + i \sin(-120°) = -1/2 - \sqrt{3}i/2$, so $1 + \rho + \rho^2 = 0$, so $d_1^2 + d_2^2 + d_3^2 = d_1^2(1 + \rho + \rho^2) = 0$, q.e.d.

Only if: Suppose $d_1^2 + d_2^2 + d_3^2 = 0$. Using (14.1.1) to eliminate d_3 we get:

$$d_1^2 + d_2^2 + d_1d_2 = 0$$

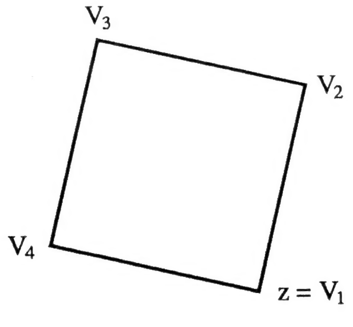
Dividing both sides by d_1^2, and letting $w = d_2/d_1$, we get:

$$w^2 + w + 1 = 0$$

whose roots are $-1/2 \pm \sqrt{3}i/2$: the complex cube roots of unity.

Thus either $w = \rho$ or $w = \rho^2$, that is, either $d_2/d_1 = \rho$, so $d_2 = d_1\rho = d_1e^{2\pi i/3}$, or $d_2 = d_1e^{4\pi i/3}$. This can be interpreted geometrically to mean that d_2 is d_1 rotated ±120°, i.e. that $|d_2| = |d_1|$ and the angle between them is 60°, i.e. the triangle is equilateral. q.e.d.

E14.2. Let z and w be two vertices of a square. Find the two other vertices (considering all possible cases).



Let the vertices be z = V1, V2, V3, V4, in counterclockwise order around the perimeter of the square (see last figure on page 3), and let $d_1 = V_2 - V_1$, $d_2 = V_3 - V_2$, $d_3 = V_4 - V_3$, $d_4 = V_1 - V_4$. Then we have $d_2 = sd_1$, $d_3 = sd_2$, $d_4 = sd_3$, where $s = e^{i\pi/4} = \cos(90°) + i \sin(90°) = i$. The three possible cases are $w = V_2$, $w = V_3$, $w = V_4$.

(1) $w = V_2$. In this case we have

$$V_3 = V_2 + d_2 = w + id_1 = w + i(w - z) = w(1 + i) - iz \text{ and}$$

$$V_4 = V_3 + d_3 = V_3 + id_2 = V_3 + i^2d_1 = V_3 - d_1 =$$
$$w(1 + i) - iz - (w - z) = iw + z(1-i)$$

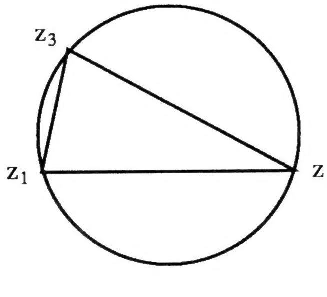
(2) $w = V_3$. In this case we have $w = z + d1 + d2 =$
$= z + d1(1 + i)$, so
$d1 = (w - z)/(1 + i)$,
$V_2 = V_1 + d_1 = z + (w - z)/(1 + i) = (iz + w)/(1 + i)$,

and

$$V_4 = V_3 + d_3 = w + i^2d_1 = w - d_1 = w - (w - z)/(1 + i) =$$
$$= (iw + z)/(1 + i)$$

(3) $w = V_4$. I'll leave this case to you.

E14.3. Find the center and the radius of the circle which circumscribes the triangle with vertices z_1, z_2, z_3. Express the result in symmetric form.



Let $z_1 = a_1 + ib_1$, $z_2 = a_2 + ib_2$, $z_3 = a_3 + ib_3$, let $C = a + ib$ be the center of the circle which circumscribes the triangle with vertices z_1, z_1, z_1, and let R be its radius.

I was surprised to find myself buffaloed by this exercise for a long time, and I almost gave up. My approach was to compute the center of the circle as the intersection of the perpendicular bisectors of the chords $z_1 \to z_2$ and $z_2 \to z_3$, but I got lost in a maze of algebra. After a long while, I found the right tack, which, in hindsight, is the obvious one:

The distance from the center of the circle to any of the points z_i is the radius R, so for two of them:

$$|C - z_1|^2 = R^2 \text{ and } |C - z_2|^2 = R^2, \text{ i.e. } |C - z_1|^2 = |C - z_2|^2.$$

Expanding this equation out, the quadratic terms in a and b vanish, and we are left with a pair of linear equations. After much relatively dull algebraic toil, we find the solution as follows, expressed in terms of the given points and, as required, symmetric in z_1, z_2, and z_3.

$$C = -\frac{i}{2}\frac{|z_1|^2 (z_2 - z_3) + |z_2|^2 (z_3 - z_1) + |z_3|^2 (z_1 - z_2)}{\Im\,[z_1^* z_2 + z_2^* z_3 + z_3^* z_1]}$$

How about the radius of the circle? Well, $R = |C - z_1|$ will do; or, if you insist (with Ahlfors) on symmetry:

$$R = \frac{|C - z_1| + |C - z_2| + |C - z_3|}{3}$$

Take as an example three points on a circle of radius r with center z_0:

$$z_1 = z_0 + re^{if},\ z_2 = z_0 + re^{ig},\ z_3 = z_0 + re^{ih}$$

I leave it as an exercise for you, dear reader, to verify that the solution given above gives us $C = z_0$ and $R = r$.

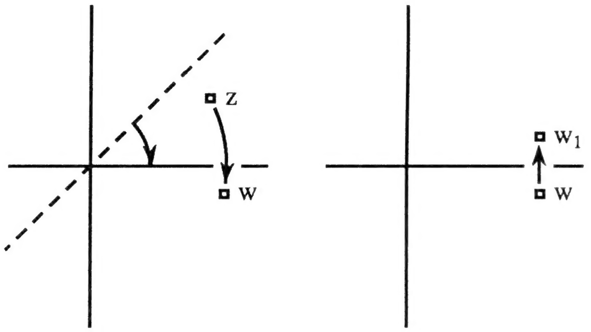
If the details of the derivation of the formula for C interest you, try to work it out for yourself. If after your best effort you can't hack it, send me a SASE and I'll send you my derivation of it, in nauseating detail.

By the way, I make heavy use of my word processor to do complicated algebra. It cuts way down on the frequency of trivial errors in doing things like moving a term from one side of an equation to the other, changing signs, distributing sums through products, etc.

E14.4. Find the points symmetric to the point z with respect to the lines which bisect the angles between the coordinate axes.

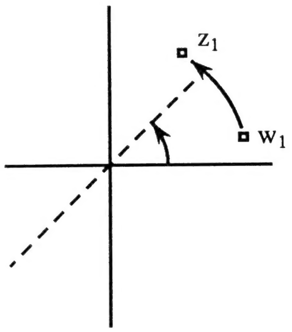
By a process of successive refinement I found two ways to solve this.

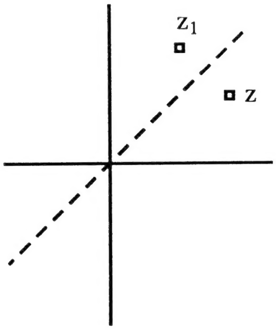
My first idea was that if we rotate the coordinate system 45° clockwise to bring the axis of symmetry into coincidence with the real axis, rotating the point z = a+ib into point w, it is clear that the point w_1 symmetric to w = c+id is w_1 = c-id, gotten by reflecting w in the x-axis.



We can then rotate the coordinate system 45° counterclockwise to bring the axis of symmetry back where it was, rotating w_1 into the point z_1 which is the desired point symmetric to z about the 45° axis, as shown in the next figure.

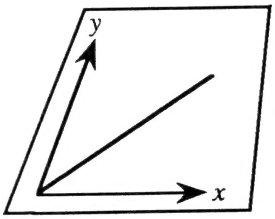
It should be clear from material presented previously in

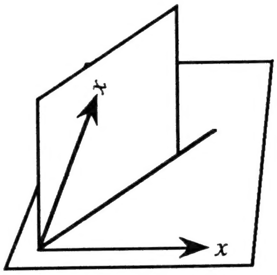




these tutorials that rotation 45° clockwise, i.e. $-\pi/4$ radians, is just multiplication by $e^{-i\pi/4} = \cos(\pi/4) - i \sin(\pi/4) = (1-i)\sqrt{2}/2$. Thus $w = ze^{-i\pi/4} = (a+ib)(1-i)\sqrt{2}/2 = [a+b + i(b-a)]\sqrt{2}/2$, and $w_1 = w^* = [a+b - i(b-a)]\sqrt{2}/2$. Rotation 45° counterclockwise, i.e. $+\pi/4$ radians, is just multiplication by the conjugate $e^{i\pi/4} = \cos(\pi/4) + i \sin(\pi/4) = (1+i)\sqrt{2}/2$. Thus $z_1 = w_1e^{i\pi/4} = [a+b - i(b-a)](1+i)/2 = b + ia$.

How simple! It appears that the point symmetric to $z = a+ib$ in the 45° axis is gotten by interchanging real and imaginary parts! Not surprising, actually. If we consider a mirror erected at right angles to the complex plane and passing through the 45° line, it is intuitively clear that the real axis is reflected into the imaginary axis, and, looking from the other side of the mirror, that the imaginary axis is reflected into the real axis.

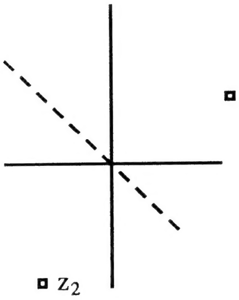


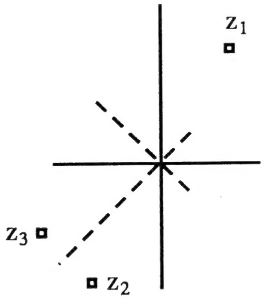


This is the second method of solving the problem: the point symmetric to z relative to the 45° axis is the reflection of z in the mirror, i.e. z with real and imaginary parts interchanged (as are the axes).

The other axis of symmetry is the -45° axis. By a similar argument by reflection we can see that the real axis and the *negative* imaginary axis are reflected into each other by a mirror erected on this axis of symmetry, so the point z_2 symmetric to $z = a+ib$ in this axis is gotten by the transformation $a \to -b$, $b \to -a$, i.e. $z_2 = -b-ia$, as shown in the left-hand figure at the top of the next column.

Finally, there is the point z_3, which is both the reflection of z_2 in the +45° axis and the reflection of z_1 in the -45° axis, as shown in the right-hand figure.





I invite any of you who have tackled Ahlfors' *Complex Analysis* and have questions, problems or difficulties to write to me; I will help if I can.

PET PEEVES OF A MAIL ORDERIST TRYING TO DO BUSINESS IN OUR GLOBAL VILLAGE, STRUCTURED ALONG THE LINES OF THE TOWER OF BABEL

PP1. Receiving letters from abroad with return addresses which leave out the most important piece of information: the COUNTRY, thus necessitating considerable research with the atlas/gazeteer, e.g.

Sweely Margon
44 Cattelya Rd.
8735 Aligarh
WHERE???

Is hisher family name Sweely or Margon? (To set an example, my father's name was Joe Silver, not Rollo Joe.)

PP2. Having to puzzle out the mailing address of an academic/institutional type which reads more like a resume than something that will fit on a label, e.g.:

Herr Professor Doctor Harronce Muckenfuss III, M.D., Ph.D., LL.D., D.D., D.V.M.,
Head,
Department of Computer Science and Extraterrestrial Biotechnology,
473 Menudo Building,
Campus Drive West,
Quaternity College,
University of Whamm,
472 Bergen, Hants, Ffoulkeshire, 6F4 9Q7 T4D
MALTA

PP3. Receiving long incomprehensible letters written in a hand which is, mirabile dictu, less legible than my own.

PP4. Getting a request for a bunch of material from a well-meaning person who encloses a teeninetsy SASE requiring folding the stuff 69 times to get it into the envelope.

BOOK REVIEW — GROWTH MORPHOGENESIS

The following review, by Robert Horvitz, has appeared in Whole Earth Review and in SIGNAL, a Whole Earth Catalog. It is reprinted here with permission of the author and Kevin Kelly of WER. It has been slightly edited as necessary to make its appearance in Amygdala more appropriate.

Growth Morphogenesis

Yoichiro Kawaguchi
1985; 212 pp.
$29.95 postpaid from
Amygdala

Yoichiro Kawaguchi's work makes use of fractals, but he's not just a finder of fruitful equations, he's a brilliant inventor of visual worlds. Colorfully patterned biomorphs, resembling sea creatures from another planet, grow, writhe, float and evolve in his video animations, while the surroundings, the observer's viewpoint and the light source all move.

The dynamism of these forms is partly captured in sequences of stills in this amply illustrated book, with texts in Japanese and English. Some of the chapters seem to be transcribed lectures by Kawaguchi; the hallucinogenic flavor of his thinking is somewhat heightened by the difficulty of translation.

Other chapters are descriptions of method and purpose by some of his collaborators, interspersed with short testimonials from his fans. The computer system (64 minis linked in parallel) and the programming concepts he uses are described in the appendix. This is some of the most exciting computer-graphic work I've ever seen.

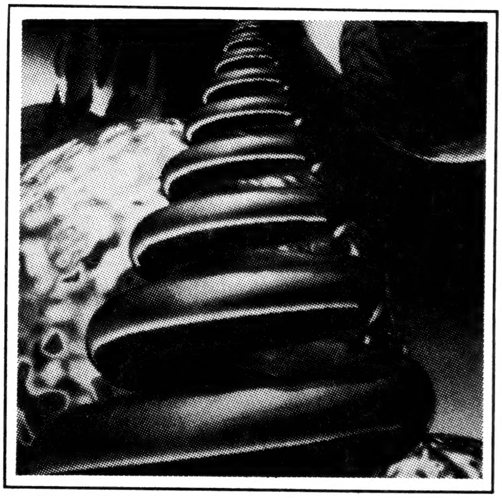
— Robert Horvitz

Self-terminating hereditary information takes a completely autonomous shape as the spiral covering the outer skin — the ascending and descending spiral completely covers the outer skin with a firm husk. That is, furthermore, like the properties of a highly acid creature.

◆

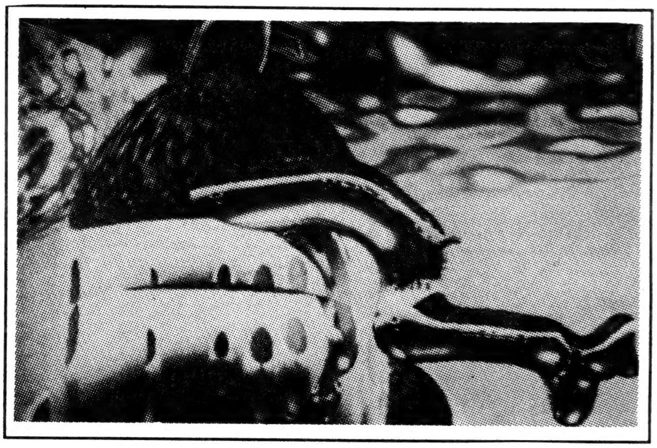
The original character which is dispatched and harmonized — the cell-like trait, which grows while sent out in liquid-state from a husk closed within a kernel, self-materializes a definitely hereditary character within a movement combining a semiorganic ionized colloid personality with the arbitrariness of the living body.

◆



Topological paradise — a resonance with intricacy and confrontation between influence and assertion fuse, so that an emotional perspective appears. This is the emergence of a world of words polished through living body rhythms and the weaving of brocade. This is probably reflected screen in the human mental world. It forms a celestial image surpassing the pain of existence bespoken by colors and common sayings.

This may well be the most sublime image that computer graphics can achieve now.



The mimesis in the level of transparency — the mimesis which has melted invisibly within the light, seems to be an art of seclusion within the bounds of human visibility. The living body is purified, and its transparency is gauged at the point at which it can no longer hold impurities inside the body cavity even by using all its might.

SOFTWARE REVIEWS

IBM PC & COMPATIBLES

"MINI-REVIEWS OF DOS MANDELBROT SOFTWARE", reviewing nine programs, is available from:

Dan Lufkin / 303 West College Terrace / Frederick, MD 21701

ATARI ST

Curtis Hoffmann's note reviewing two Atari ST programs (**MyLife20** and **YAFractl**) is available from **Amygdala** for a 25¢ SASE.

SLIDE SUBSCRIPTION RENEWAL

Many current supplementary slide subscriptions run though C16: the set of four color slides that will accompany newsletter #16.

A new subscription for 24 slides to be distributed with newsletters #17-22 is available for $19.20 ($20.00 overseas); or for 40 slides to be distributed with newsletters #17-26, for $27.00 ($35.00 overseas).

Be sure that your renewal reaches me before #17 is sent out.

A LETTER FROM CLIFF PICKOVER

I enjoy **Amygdala** wholeheartedly and want to commend Rollo for the fine job he does! I notice that Rollo occasionally cites some of my papers in the Bibliography section, and I would be happy to send Amygdala readers free photocopies of any of these papers which they find hard to find. Just drop me a note.

I'd like to invite Amygdala readers to submit slides and articles to the new "Chaos and Graphics Section" of *Computers and Graphics,* an international Pergamon Press journal. I am an associate editor of *Computers and Graphics* with control over this special section. To eliminate any confusion, this is a "real" journal, in contrast to my informal newsletter which Rollo has mentioned in the past. If any of you have any beautiful high-resolution, color (or as a second choice, high-resolution black and white) fractal or related images which you feel are novel and particularly pretty, why not send them to me for consideration? If the pictures are judged interesting, you would then be asked to write a short note describing the figures and their generation.

Most of the beautiful slides supplied with Amygdala, and the accompanying Amygdala articles, are certainly candidates for the Pergamon Press journal. We publish color and we would certainly give a "plug" to Amygdala for any material that first appeared here. This should help popularize Rollo's wonderful newsletter.

Thanks,
Dr. Cliff Pickover, Assoc. Editor
Computers & Graphics
IBM Watson Research Center
Yorktown Heights, NY 10598 USA

CHAOTIC BOOKS (AND OTHERS)

Chaos: Making a New Science

—*James Gleick*

The Butterfly Effect
Revolution
Life's Ups and Downs
A Geometry of Nature
Strange Attractors
Universality
The Experimenter
Images of Chaos
The Dynamical Systems Collective
Inner Rhythms
Chaos and Beyond

◆ Where Chaos begins, classical science stops. For as long as the world has had physicists inquiring into the laws of nature, it has suffered a special ignorance about disorder in the atmosphere, in the turbulent sea, in the fluctuations of wildlife populations, in the oscillations of the heart and the brain. The irregular side of nature, the discontinuous and erratic side — these have been puzzles to science, or worse, monstrosities.

A Topological Picture Book

—*George K. Francis*

1. DESCRIPTIVE TOPOLOGY
2. METHODS AND MEDIA
3. PICTURES IN PERSPECTIVE
4. THE IMPOSSIBLE TRIBAR
5. SHADOWS FROM HIGHER DIMENSION
6. SPHERE EVERSIONS
7. GROUP PICTURES
8. THE FIGURE EIGHT KNOT

Color Plates
BLACKBOARD DUNCE CAP
DIAPERED TREFOIL KNOT
CROSS CAP AND LIMAÇON
ETRUSCAN VENUS

◆ My book is about how to draw mathematical pictures. Of course, it begs the question of whether one should draw pictures in mathematics in the first place. Some disciplines require illustrations. Imagine Gray's Anatomy without pictures. Some get along better without them. Imagine trying to illustrate Russell and Whitehead's Principia.

◆ The story of everting spheres in 3-space by regular homotopies is the case history of a nontrivial visualization problem of remarkable complexity and compelling beauty. The task is to show the motion of a spherical surface through itself in space so that, without tearing or creasing, the surface is turned inside out.

The Armchair Universse

—A. K. Dewdney

WORLD ONE: Infinite Graphics
WORLD TWO: Mathemagadgets
WORLD THREE: Artificial Intelligence and Artificial Insanity
WORLD FOUR: Life in Automata
WORLD FIVE: Puzzles and Wordplay
WORLD SIX: Stimulation through Simulation
WORLD SEVEN: Core Wars

◆ The armchair universe contains many worlds, each accessible through the magic of computing. An office, study, or living room becomes a spaceship, provided it is equipped with a computer and an armchair. The computer (whether micro or mainframe) is loaded with one or more of the programs outlined in this book. The armchair is occupied by the reader ready for high adventure in the infinitesimal reaches of the Mandelbrot set, the mind-bending four-dimensionality of hypercubes, the graceful ballet of a cluster of stars.

Chaotic Dynamics and Fractals

—Michael F. Barnsley and Stephen G. Demko

1. Chaos and Fractals
2. Julia Sets
3. Applications

◆ This collection of papers deals with the research area of chaos, dynamical systems, and fractal geometry. Here, current interest by the scientific and mathematical community is intense, and promises to increase over the next few years, alongside the growing usage of computer graphical techniques.

From Clocks to Chaos

—Leon Glass and Michael C. Mackey

1. Introduction: The Rhythms of Life
2. Steady States, Oscillations, and Chaos in Physiological Systems
3. Noise and Chaos
4. Mathematical Models for Biological Oscillators
5. Initiation and Termination of Biological Rhythms
6. Single Pulse Perturbation of Biological Oscillators
7. Periodic Simulation of Biological Oscillators
8. Spatial Oscillations
9. Dynamical Diseases

◆ This book deals with the applications of mathematics to the study of normal and pathological physiological rhythms. It is directed toward an audience of biological scientists, physicians, physical scientists, and mathematicians who wish to read about biological rhythms from a theoretical perspective.

The Lorenz Equations: Bifurcations, Chaos, and Strange Attractors

— Colin Sparrow

1. INTRODUCTION AND SIMPLE PROPERTIES
2. HOMOCLINIC EXPLOSIONS: THE FIRST HOMOCLINIC EXPLOSION
3. PRETURBULENCE, STRANGE ATTRACTORS AND GEOMETRIC MODELS
4. PERIOD DOUBLING AND STABLE ORBITS
5. FROM STRANGE ATTRACTOR TO PERIOD DOUBLING
6. SYMBOLIC DESCRIPTION OF ORBITS: THE STABLE MANIFOLDS OF C1 AND C2
7. LARGE r
8. SMALL b
9. OTHER APPROACHES, OTHER SYSTEMS, SUMMARY AND AFTERWORD

◆ In 1963 E. N. Lorenz wrote a remarkable paper. In it he described a three parameter family of three-dimensional ordinary differential equations which appeared, when integrated numerically on a computer, to have extremely complicated solutions.

LETTER FROM JOHN COCKING

—John Cocking

I have found a simple iteration formula which generates Feigenbaum's number, or something pretty close to it:

$x \mapsto \log(4+x)$

This iteration produces the following value as a limit:

4.669246...

According to Peitgen and Richter, Feigenbaum's number is:

4.669201...

The numbers seem too close for this to be a coincidence. This result will probably not shake the foundations of mathematics, but as far as I know, it's new.

PRODUCTS

ART MATRIX; PO Box 880; Ithaca, NY 14851 USA. (607) 277-0959. "Nothing But Zooms" video, Prints, FORTRAN program listings, postcard sets, slides. Send for FREE information pack with sample postcard. Custom programming and photography by request. Make a bid.

CIRCULATION

As of March 2, 1989 Amygdala has 574 subscribers, 241 of whom have the supplemental color slide subscription.